POST-TRAINING PERFORMANCE CRITERION DEVELOPMENT AND APPLICATION

A Multidimensional Scaling Analysis of the Circuit Types Repaired by Naval Aviation Electronics Technicians

Prepared For
Personnel and Training Branch
OFFICE OF NAVAL RESEARCH
Under Contract Nonr-2279(00)

Applied Psychological Services
Wayne, Pennsylvania

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ABSTRACT

This is the third in a series of studies investigating the applicability of multidimensional scaling techniques in the job performance area. In this study, the circuits repaired by Naval aviation electronics technicians in the performance of their duties were used as the stimulus materials. Similarity judgments among the circuit pairs were made by supervisory personnel and analyzed by multidimensional scaling methods.

It is concluded that it is feasible and fruitful to apply multidimensional scaling techniques to the classification of electronic circuits worked on in the performance of Naval jobs. The avionic circuits repaired by Naval aviation electronics technicians, as represented in the circuit list developed in the study, were perceived as involving sixteen underlying dimensions.

ACKNOWLEDGMENTS

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The successful completion of three studies into the applicability of multidimensional scaling techniques in the job performance area has depended upon the interest and efforts of a number of other knowledgeable persons to whom we are very grateful. Dr. G. Douglas Mayo, Staff, Chief of Naval Air Technical Training Command, has discussed many of the problems with us and provided liaison with administrative and technical school personnel. Liaison with fleet personnel was ably provided by LCDR F. S. Siddall of the Staff of the Commander Naval Air Force, U. S. Atlantic Fleet. Dr. David R. Saunders performed the factor analytic calculations on a high-speed computer. Tabulating and computational requirements were met by Miss Marita Viglione at Applied Psychological Services. The secretarial and administrative support was provided by Miss Gail Gensemer and Mrs. Estelle Siegel of the Applied Psychological Services staff.

We are pleased to record here our appreciation for the contributions to the program made by these people.

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CHAPTER I

INTRODUCTION

In its search for general laws, science often attempts to reduce a complex set of variables to a smaller number of fundamental, underlying variables. The organization of knowledge in terms of "building blocks" is presumed to increase both the simplicity of the formal statement of laws and the understanding of the phenomenon under examination. Although stating laws simply is generally considered to possess merit, the more important reason for identifying underlying factors is the enhancement of knowledge and understanding. Thurstone stressed this role of variable reduction in the growth of knowledge when he stated:

> "The criterion by which a new ideal construct in science is accepted or rejected is the degree to which it facilitates the comprehension of a class of phenomena which can be thought of as examples of a single construct rather than as individualized events. It is in this sense that the chief object of science is to minimize mental effort" (1947, p. 52).

It is not necessary that a selected set of variables, examined from the standpoint of possible reduction to fewer underlying factors, be the only possible set that can be generated with respect to an object or series of events. For example, an automobile may be viewed as a transport device and a group of measures related to that concept can be developed and analyzed. On the other hand, one might be concerned with the effects of the automobile on the family's economic status or on urban development, in which case different, though internally complete, sets of variables might be used. In the same manner, behavior may be examined in terms of its causes,its effects, its characteristic manifestations, etc. Within each defined class of variables, a consistent underlying structure may be developed whose utility will normally be limited only by the adequacy and ease with which the substrate accounts for, or reproduces, those variables. Each group of underlying variables may be considered as "basic" in the sense that it "...facilitates the comprehension of a class of phenomena which can be thought of as examples of a single construct rather than as individualized events."

It is reasonable, then, that analyses of different constructs might produce different types of "fundamental factors." Furthermore, it would seem likely that combining such groups of factors in an interactive manner should lead to considerably broader comprehension of the phenomenon being studied.

In considering the nature of a job, it is not difficult to conceive of several different classes of variables that can be generated. For example, Palmer and McCormick (1961) have differentiated "worker oriented" job descriptions, emphasizing worker activities, from "job oriented" descriptions, emphasizing the technological aspects of the job. A job might be viewed from the standpoint of the materials used or its end products. Or one might work within the framework of the worker requirements, i.e., the skills, knowledges, and other personal characteristics needed for adequate job performance. Other types of variables could be mentioned. Analysis of each class of job related variables is probably useful in answering certain questions and, in concert, such varied analyses should lead to a more thorough understanding of a job.

Two recent Applied Psychological Services' studies (Schultz and Siegel, 1962; Siegel and Schultz, 1963) explored the applicability of multidimensional scaling techniques to two levels of the job of the Naval aviation electronics technician (AT). In this research, the job was analyzed in terms of the <u>tasks performed</u> by the typical AT in the Fleet. In the first study (Schultz and Siegel, 1962), four basic dimensions were found to account for the AT job at the striker and petty officer, third class, level; nine dimensions were extracted in the study of AT supervisory personnel (Siegel and Schultz, 1963), including all four of the dimensions characterizing the lower job level.

Methodologically, these studies demonstrated the feasibility and fruitfulness of applying multidimensional scaling techniques in the job performance area through use of the specific methods that were developed for this purpose. The nature of and the rationale underlying multidimensional scaling analysis, as well as its relevance for job performance measurement, have been fully discussed in the earlier reports. Essentially, multidimensional scaling provides procedures designed to account for the perceptions of the psychological distances amoung a set of stimuli in terms of a minimum number of basic dimensions. The source data are usually judgments of over-all similarity among the stimuli and the outcomes are (1) the number of axes which account for the space defined by the judgments and (2) the projections of the stimuli on the axes.

Another possible approach to gaining an understanding of the electronics technician's job would be to view it from the standpoint of the kinds of equipment on which the technician works. At a more molecular level, the avionic circuits involved in that family of equipments might be examined. If groups of circuits could be isolated that are independent of each other in the sense that within group repairs call for the same worker behaviors while repairs of different groups call for different worker behaviors, it should then be possible to describe any particular mission in terms of such circuit type demands and/or to evaluate personnel separately with respect to their ability to repair each different circuit type. It might also be possible to build a cross-dimensional construct of the AT job by relating each of the task dimensions previously extracted to each of the circuit types.

Purposes of the Present Study

The present study was designed to extend the investigation of the applicability of multidimensional scaling techniques in the job performance area to the types of circuits worked on by Naval aviation electronics technicians.

The specific purposes were to: (1) assess the value of multidimensional scaling techniques for classifying electronic circuits, (2) adapt and investigate the applicability to electronic circuits of previously devised methods for utilizing these techniques, and (3) determine the number and the nature of the dimensions underlying the circuits repaired by Naval aviation electronics technicians.

CHAPTER II

DEVELOPMENT AND ADMINISTRATION OF CIRCUIT LIST

The previous two Applied Psychological Services' studies of the applicability of multidimensional scaling techniques to job performance (Schultz and Siegel, 1962; Siegel and Schultz, 1963) had developed and utilized forms and procedures for obtaining the basic data required for multidimensional scaling in a job performance context. The same methods, adapted to fit electronic circuitry content, were used in this research.

Preliminary Circuit List

The focus of the research described in this report was on the electronic circuits found in the equipment which is characteristically repaired by Naval aviation electronics technicians (AT's). A preliminary list of these circuits was prepared by a design engineer who has had considerable, diversified experience with a multiplicity of systems and types of circuits. He was asked to include all the different circuits that an AT might normally be expected to encounter, at a level of abstraction that would result in a number of circuits which would make feasible obtaining the needed similarity comparisons. The degree of detail inherent in the experimental outcomes was to a large extent determined by this specification.

The preliminary list was composed of the names of 34 circuit types, which were assembled in booklet form. The following directions were given on the cover page of the booklet:

> The purpose of this questionnaire is to determine the circuits in which AT's isolate malfunctions and/or which AT's repair in the Fleet. We want to obtain a list of the circuits worked on by a representative sailor in this rating.
>
> First, look over the list to get an idea of what circuits are included. Then:
>
> 1. Go through the list and check in the column labeled "AT Striker/3rd Cl." all the circuits which are <u>normally and characteristically worked on (isolating malfunctions in and/or repairing) by Striker and Third Class AT's in the Fleet.</u>
>
> 2. Go back and place a check in the second column next to all the circuits which are <u>normally and characteristically worked on (isolating malfunctions in and/or repairing) by First Class and Chief AT's in the Fleet.</u>
>
> You may know of a particular sailor who has isolated malfunctions in and/or repaired some of the listed circuits, even though most AT's do not. Or, in a particular squadron with which you are familiar, the AT's may work on certain circuits not normally encountered by most of the men in this rating. Do <u>not</u> check such circuits.
>
> If there are any circuits normally worked on (isolating malfunctions in and/or repairing) by AT's in the Fleet which are not included in the questionnaire, please write them in under "Other" on the last page. Be sure to check whether these circuits are worked on by Strikers and Third Class men or by First Class men and Chiefs or by both.

The intent of the last paragraph was to provide the opportunity for the respondents to expand the list to include any types of circuits overlooked by the engineer who constructed it.

Final Selection of Circuits

The form containing the preliminary list of circuits was administered, in two groups, to 22 instructors assigned to the AT school at the Naval Air Technical Training Command in Memphis, Tennessee. All of these instructors had made analogous judgments regarding the tasks performed by the typical aviation electronics technician, data which provided the "raw material" for the previous multidimensional analyses. Their qualifications for making these critical judgments were impressive: they were chief petty officers or petty officers, first or second class, in the AT rating, had recently arrived at the school from Fleet duty, had an average of about 7.5 years of military experience in electronics or electrical work, had an average of about 5.5 years of experience as an AT, and had been assigned as an AT to an average of about 2.25 different squadrons during their careers.

Following completion of the form by the instructors, the groups were asked for informal comments as to the over-all completeness of the list and any other aspect of the responses that had been requested of them. Although they felt generally somewhat less at ease with the circuit list than they had felt with the task list, there were no serious criticisms or major corrections mentioned.

Examination of the responses revealed that very few circuit names had been added to the list in the spaces provided for "other" circuits;

because of their limited generality and their apparent lack of general acceptance by the group, those which had been added did not appear to warrant further attention.

There was a very high degree of agreement among these experienced men as to which of the circuits are worked on by typical chief petty officers and petty officers, first class, in the AT rating. Out of the total of 34 possible circuits, 31 were checked by 18 or more of the instructors and 30 of these were checked by 20 or more men There was considerably less agreement with respect to the circuits the typical strikers and petty officers, third class, repair. The frequency with which a specific circuit was chosen scattered from 4 to 22. However, the 31 circuits mentioned above included all those relating to the striker level down to a selection frequency of 10. Out of the original list of circuit types, the 31 excluded only phototube, induction motor, and resonator.

From these data, then, it appeared that the 31 circuits checked by 18 or more of the judges included all the circuit types that are normally worked on by aviation electronics technicians. although some of these would not necessarily be encountered until the sailor reaches the higher levels in the rating. <u>These 31 circuits, therefore, were taken as the basis for the multi-dimensional scaling analysis of circuit types</u>:

1. Mixer
2. Cathode follower
3. Klystron
4. Waveguide
5. Attenuator
6. Servomechanism
7. Ringing
8. Magnetron
9. Single-shot multivibrator
10. Flip-flop
11. Transformer
12. Filter
13. Thyratron trigger
14. Detector
15. Voltage doubler
16. Automatic frequency control
17. Rectifier
18. Bridge
19. Sweep oscillator
20. Frequency discriminator
21. Modulator
22. RF oscillator
23. Regulator
24. Blocking oscillator
25. Integrator
26. Clipping
27. Peaking
28. DC restorer
29. Cathode ray tube
30. Differentiator
31. Inverter

The Multidimensional Scaling Form

A booklet was devised so that judgments of the similarity between each pair of circuits could be obtained through group administrative procedures. At the top of each page, one of the 31 circuit names was presented. Below it, along the left side of the page, from one to all (30) of the remaining circuit names appeared in columnar form. The number of circuit names listed on any page was variable because the judgment of similarity between each pair of circuits was requested only once from each respondent. If circuit "B" had been compared to circuit "A" appearing at the top of a page, circuit "A" was not included in the list when "B" appeared at the top of a page. The circuits on each page were presented in a random order which differed from one page to another.

A scale of 11 points was printed to the right of each circuit name. Scale points 1 and 2 were labeled as representing a judgment of "very similar"; points 3, 4, and 5, were labeled as representing "moderately similar"; points 7, 8, and 9 were labeled as representing "moderately different" and points 10 and 11 represented "very different." Scale point 6, in the middle of the scale range, was not described. The booklet page which contained all the circuits is shown as Table 1; a sample of the other pages is shown as Table 2.

The booklet was called the Technical Circuit Inventory. After giving a brief statement of the purpose of the questionnaire and the page layout, the directions said, "You should think about working on (that is, isolating malfunctions in and/or repairing) each circuit in the list as compared with working on the circuit at the top of the page. Then, you should place a check in the appropriate column to the right to indicate how similar or different you think working on the two circuits is." Responses to three illustrative comparisons

Table 1

Page of the Technical Circuit Inventory Containing all Circuits

MIXER

	VERY SIMILAR		MODERATELY SIMILAR				MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5	6	7	8	9	10	11
TRANSFORMER											
DETECTOR											
SINGLE-SHOT MULTIVIBRATOR											
CATHODE RAY TUBE											
MODULATOR											
MAGNETRON											
FLIP-FLOP											
WAVEGUIDE											
ATTENUATOR											
CLIPPING											
RECTIFIER											
AUTOMATIC FREQUENCY CONTROL											
BRIDGE											
SWEEP OSCILLATOR											
CATHODE FOLLOWER											
RINGING											
FILTER											
RF OSCILLATOR											
DIFFERENTIATOR											
DC RESTORER											
KLYSTRON											
THYRATRON TRIGGER											
INVERTER											
PEAKING											
VOLTAGE DOUBLER											
FREQUENCY DISCRIMINATOR											
BLOCKING OSCILLATOR											
SERVOMECHANISM											
INTEGRATOR											
REGULATOR											

Table 2

Sample Page of the Technical Circuit Inventory

DETECTOR

	VERY SIMILAR		MODERATELY SIMILAR				MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5	6	7	8	9	10	11
REGULATOR	___	___	___	___	___	___	___	___	___	___	___
MODULATOR	___	___	___	___	___	___	___	___	___	___	___
BLOCKING OSCILLATOR	___	___	___	___	___	___	___	___	___	___	___
DC RESTORER	___	___	___	___	___	___	___	___	___	___	___
INVERTER	___	___	___	___	___	___	___	___	___	___	___
FREQUENCY DISCRIMINATOR	___	___	___	___	___	___	___	___	___	___	___
BRIDGE	___	___	___	___	___	___	___	___	___	___	___
AUTCMATIC FREQUENCY CONTROL	___	___	___	___	___	___	___	___	___	___	___
VOLTAGE DOUBLER	___	___	___	___	___	___	___	___	___	___	___
RECTIFIER	___	___	___	___	___	___	___	___	___	___	___
INTEGRATOR	___	___	___	___	___	___	___	___	___	___	___
RF OSCILLATOR	___	___	___	___	___	___	___	___	___	___	___
DIFFERENTIATOR	___	___	___	___	___	___	___	___	___	___	___
CLIPPING	___	___	___	___	___	___	___	___	___	___	___
CATHODE RAY TUBE	___	___	___	___	___	___	___	___	___	___	___
PEAKING	___	___	___	___	___	___	___	___	___	___	___
SWEEP OSCILLATOR	___	___	___	___	___	___	___	___	___	___	___

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were presented and the respondent was given the opportunity to practice check two more. The complete cover page of the form, including the directions, is shown in Table 3.

The number of circuits appearing on a page could vary widely from one page of a booklet to the next, because a table of random numbers was used to establish the order of pages. Four different random page orders were used, the forms being intermixed for administration.

Subjects

The subjects for this study were the same as those used in the previous two applications of multidimensional scaling analysis. The group consisted of 31 chief petty officers and 34 petty officers, first class, in the Naval aviation electronics technician (AT) rating. Table 4, also presented in the earlier reports, shows the squadrons to which these judges were assigned and their locations. The men had an average of 11.2 years of military experience in electronics or electrical work, had been AT's for an average of 8.3 years, and had been assigned as an AT to an average of 3.8 squadrons.

Administration

The Technical Circuit Inventory was administered to the subjects during the same group sessions as the Technical Task Inventories, the analysis of which was given in two previous reports of this series. Following

Table 3

Cover Page of the Technical Circuit Inventory

Name____________________________ Today's Date________________

TECHNICAL CIRCUIT INVENTORY

The purpose of this questionnaire is to compare isolating malfunctions in and/or repairing various electronic circuits.

The name of one type of circuit is shown at the top of each page. Below it is a list of other types of circuits. You should think about working on (that is, isolating malfunctions in and/or repairing) each circuit in the list as compared with working on the circuit at the top of the page. Then, you should place a check in the appropriate column to the right to indicate how similar or different you think working on the two circuits is. There are no "right" or "wrong" answers to this Inventory, your best judgments of similarity are the only "right" answers.

Before you begin, open the booklet and look over the pages briefly to get an idea of what circuit types are included. Notice that the pages have different numbers of circuits listed. Then start working at the beginning of the booklet. Try to vary your check marks so that some appear in all eleven columns. Do not hesitate to use the extreme responses numbered 1 and 11, if you feel any comparison deserves one of them.

EXAMPLE

RESONATOR

	VERY SIMILAR		MODERATELY SIMILAR				MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5	6	7	8	9	10	11
PHOTOTUBE											✓
COUPLING					✓						
INDUCTION MOTOR			✓								
RECTIFIER											
BRIDGE											

The first check means that the person completing the Inventory thinks that isolating malfunctions in and/or repairing phototube circuits is very different from isolating malfunctions in and/or repairing resonator circuits. The second check means that the person answering feels that working on coupling circuits is moderately similar (to the degree indicated by a "5") to working on resonator circuits. According to the check on the third line, working on induction motor circuits is moderately similar (to the degree indicated by a "3") to working on resonator circuits. You may or may not agree with this person. Try filling in the last two lines yourself.

WHEN YOU HAVE FINISHED, CHECK BACK TO MAKE CERTAIN YOU HAVE PLACED A CHECK NEXT TO EACH TASK IN THE LIST OF EVERY PAGE.

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Table 4

Numbers of Subjects by Location and Squadron

Location	Squadron	Number
Norfolk	FAETULANT	29
	HS 3	2
	HS 7	2
	VP 24	2
	VP 56	3
	VRC 40	2
	VRF 31	1
	VS 26	2
	VU 6	3
Oceana	VA 42	2
	VA 43	10
	VA 75	1
	VF 101 Det. A	5
	VU 2	1
		65

a brief, general explanation of the purpose of the research, the subjects completed the two forms relating to job tasks. Then a short rest period was given and a few biographical facts were requested. This was followed by the administration of the Technical Circuit Inventory. Almost all the subjects finished the three forms before the end of the three-hour period, but no time limits were imposed on any of the forms.

Although, as mentioned in the earlier reports, the subjects were able to understand their task with no apparent difficulty and all the forms were essentially self-administering, some comments and informal conversations suggested that the subjects were somewhat more uneasy with their responses to the Circuit Inventory than they had been with their responses to the Task Inventories.

CHAPTER III

THE MULTIDIMENSIONAL SCALING ANALYSIS

The method of equal appearing intervals was used to scale the inter-circuit similarity judgments. Use of this approach involved the assumption that the subjects perceived the similarity scale categories as equal. Although the category widths were not explicitly defined in the directions for the Technical Circuit Inventory or in the labeling of the scale, it seemed reasonable to make this assumption which underlies the equal appearing intervals method. Additionally, research recently completed by Applied Psychological Services has suggested that, for job oriented judgments, use of the equal appearing or the successive interval scales exerts little difference on the resulting dimensionality.

The median judgment indicated by the 65 subjects was taken to be the scale value of each circuit pair. For purposes of multidimensional scaling analysis, this scale value is interpreted as the relative psychological distance between that pair of circuits. As mentioned above, the goal of the analysis is to determine the number of axes in the space which accounts for the structure defined by these distances among all the stimuli (circuits), and also to determine the projections of each circuit on each of the axes.

For each of the 465 circuit pairs of the Technical Circuit Inventory, the scale value, or inter-circuit distance, is shown in Table 5.

Table 5

Relative Inter-Circuit Distances, Technical Circuit Inventory
(Obtained from group of 65 subjects)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	----	6.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.58	4.44	8.63	[illegible]	8.67	8.45	8.59	8.88	9.44	7.79	9.00
2		----	[illegible]	[illegible]	7.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.56	8.13	8.58	8.17	[illegible]	8.36	8.45	8.50	8.59	6.36	9.25	7.65	9.00
3			----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.72	7.77	[illegible]	8.08	7.38	[illegible]	[illegible]	8.50	9.13	[illegible]	9.14	[illegible]
4				----	4.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.88	9.38	7.21	9.32	[illegible]	[illegible]	9.57	9.36	9.34	[illegible]	9.34	9.72
5					----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.77	[illegible]	6.64	[illegible]	7.82	[illegible]	[illegible]	9.32
6						----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.88	8.68	8.93
7							----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.54	9.93	7.75	[illegible]
8								----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.67	[illegible]
9									----	[illegible]	[illegible]	[illegible]	[illegible]	8.56	[illegible]	[illegible]	[illegible]	[illegible]	4.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.94	[illegible]	8.45	[illegible]	8.67	[illegible]
10										----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.81	[illegible]	7.68	9.76	7.31	8.36
11											----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.07	[illegible]	[illegible]	8.25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9.92	[illegible]	[illegible]
12												----	[illegible]	[illegible]	[illegible]	7.27	[illegible]	[illegible]	[illegible]	6.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.06	7.67	[illegible]
13													----	[illegible]	[illegible]	[illegible]	[illegible]	8.72	[illegible]	7.88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.42	[illegible]	6.39	[illegible]
14														----	6.68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.44	[illegible]	[illegible]	[illegible]	[illegible]	7.44	[illegible]
15															----	[illegible]	[illegible]	[illegible]	[illegible]	8.25	[illegible]	[illegible]	[illegible]	[illegible]	6.72	8.55	[illegible]	[illegible]	[illegible]	7.95	8.56
16																----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.23	7.56	[illegible]	7.45	9.25
17																	----	[illegible]	[illegible]	[illegible]	[illegible]	8.75	[illegible]	[illegible]	6.27	6.95	[illegible]	4.77	[illegible]	[illegible]	7.83
18																		----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.77	8.44	8.67	7.45	9.92	[illegible]	[illegible]
19																			----	[illegible]	[illegible]	[illegible]	8.25	[illegible]	[illegible]	6.28	[illegible]	[illegible]	9.23	[illegible]	9.36
20																				----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.13	7.92	[illegible]	6.93	8.81
21																					----	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.17	[illegible]	[illegible]	8.23	8.45
22																						----	[illegible]	[illegible]	[illegible]	8.64	8.36	8.45	[illegible]	8.08	8.61
23																							----	[illegible]	8.45	[illegible]	8.75	4.95	9.88	8.65	[illegible]
24																								----	[illegible]	[illegible]	[illegible]	7.63	9.97	7.79	8.93
25																									----	6.94	5.17	6.06	10.10	[illegible]	9.11
26																										----	6.06	4.61	9.86	4.92	7.43
27																											----	7.07	9.74	4.44	9.03
28																												----	9.28	7.17	8.83
29																													----	9.85	9.71
30																														----	8.86
31																															----

When the entries of Table 5 are compared with the entries of the analogous tables in the two earlier reports of multidimensional scaling analyses (Schultz and Siegel, 1962; Siegel and Schultz, 1963), it is seen that the inter-circuit values are generally higher than the inter-task values. The mean inter-circuit distance shown in Table 5 is 7.95, while the means of the inter-task distances in the previous studies were 5.50 and 4.98. Thus, the subjects indicated that the circuits were generally less similar to one another than were the tasks.

<u>The Dimensionality Analysis</u>

The customary multidimensional scaling procedures were applied to the data of Table 5. The general solution to the additive constant problem proposed by Messick and Abelson (1956) was followed to produce a value which, when added to the relative distances of Table 5, would result in a ratio scale of absolute distances. The constant so determined was 2.03. The smallest judged inter-circuit distance is 1.79; therefore, the smallest corrected distance became 3.82.

The matrix B^* was then obtained, consisting of the scalar products of the vectors to points with an origin at the centroid of the stimuli. This matrix is given in Appendix A of this report.

The B^* matrix was factored by the method of principal components, resulting in the matrix F, presented in Appendix B. The rank of matrix F

is sixteen. The matrix of residuals, after extraction of the sixteen dimensions from the matrix B^* is given in Appendix C.

The sixteen axes of matrix F were rotated to orthogonal, simple structure as determined by the normal equamax criterion, an analytical solution to the problem of factor rotation developed by Saunders (1962). The transformation matrix is presented in Table 6 and the final matrix of projections of the stimuli (circuits) on the rotated axes is shown in Table 7.

Interpretation of Dimensions

The circuits with the highest projections (loadings) on each dimension are presented in Tables 8 through 23. Examination of the data in these tables led to the selection of the names listed below for the sixteen dimensions. Since the reasons for the names appear rather self-evident, no further explanation seems necessary. In each case, the dimensional orientation of the group of task loadings on which the name is based is also given.

Table No.	Dimension No.	Name	Orientation
8	I.	Frequency reducing circuits	Positive
9	II.	Triggered circuits	Positive
10	III.	Regulating circuits	Negative
11	IV.	Error compensating circuits	Positive
12	V.	Power supply circuits	Negative
13	VI.	Electron beam displacement circuits	Positive
14	VII.	Balancing circuits	Positive
15	VIII.	Wave shaping circuits	Negative

Table 6

Transformation Matrix

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	0.36	-0.27	-0.22	0.24	-0.41	0.08	0.43	-0.09	-0.28	0.41	0.09	0.17	0.05	-0.17	-0.03	-0.06
II	-0.29	0.40	0.20	0.48	0.00	-0.01	-0.11	-0.37	-0.33	0.05	0.21	0.23	-0.04	0.03	0.35	-0.03
III	0.50	-0.24	0.17	-0.34	0.37	0.03	-0.15	-0.44	-0.27	-0.11	0.04	0.02	0.07	0.02	0.26	-0.17
IV	-0.05	-0.14	0.55	0.16	-0.03	-0.29	0.07	0.05	0.00	0.13	-0.30	0.10	0.44	0.28	-0.25	-0.32
V	0.05	0.03	-0.60	0.34	0.27	-0.09	-0.07	-0.14	0.25	0.01	-0.26	-0.12	0.44	0.01	0.19	-0.19
VI	0.33	0.50	0.01	0.04	0.20	0.45	-0.02	0.25	-0.06	-0.08	-0.12	0.37	0.07	-0.17	-0.30	-0.22
VII	-0.43	-0.49	0.09	0.05	0.16	0.63	0.01	-0.04	0.00	0.02	-0.21	0.20	0.12	-0.13	0.09	0.11
VIII	0.10	0.10	0.07	-0.06	0.02	-0.26	-0.22	-0.04	-0.03	0.34	-0.64	0.17	-0.18	-0.34	0.11	0.37
IX	-0.26	0.07	0.06	-0.09	0.02	-0.08	0.07	-0.08	-0.27	-0.05	-0.01	-0.45	0.12	-0.69	-0.17	-0.31
X	0.13	0.22	0.15	-0.01	-0.41	0.43	0.01	-0.24	0.17	0.05	-0.35	-0.47	-0.13	0.21	0.17	-0.17
XI	0.27	-0.23	0.13	0.36	-0.31	0.04	-0.56	0.33	-0.09	-0.29	0.09	-0.11	0.17	-0.19	0.14	0.09
XII	-0.11	-0.19	-0.11	0.01	0.02	-0.09	-0.17	0.28	0.00	0.13	-0.09	0.15	-0.51	0.03	0.24	-0.67
XIII	0.04	-0.08	-0.11	0.30	0.31	0.03	0.11	0.18	-0.57	-0.12	-0.26	-0.34	-0.26	0.32	-0.19	0.16
XIV	0.13	0.07	0.28	0.09	0.38	0.10	0.15	0.38	0.15	0.50	0.26	-0.31	0.08	-0.06	0.34	0.09
XV	0.20	-0.17	0.22	0.46	0.21	-0.06	0.19	-0.27	0.46	-0.22	0.03	-0.02	-0.39	-0.23	-0.21	0.00
XVI	0.03	0.07	0.09	-0.05	-0.07	-0.13	0.55	0.25	-0.03	-0.50	-0.23	0.12	0.07	-0.10	0.51	0.02

Table 7

Final Matrix of Projections of Circuits on Dimensions

Dimension Number

Task No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
1	-0.29	-0.23	0.43	0.58	0.82	-0.18	0.14	0.72	1.01	0.63	-6.42	0.96	0.41	0.42	-0.28	0.84
2	0.03	-0.03	0.62	0.65	0.41	0.40	-0.14	0.24	0.13	0.46	-0.66	7.15	-0.37	0.10	-0.29	-0.34
3	-1.81	-1.84	2.57	-2.72	1.11	-0.79	0.03	0.94	1.59	-3.67	-1.33	-2.26	0.58	0.48	-1.51	-0.63
4	3.52	-1.40	0.21	-6.61	0.39	0.31	0.42	0.90	0.80	-1.10	0.65	-0.94	-0.27	-0.07	-0.71	-1.24
5	6.80	-0.60	0.27	-1.97	1.11	0.28	0.41	0.51	-1.84	-0.31	0.20	1.65	-0.09	-0.12	-0.32	-0.82
6	-0.82	-0.58	-7.66	0.65	1.94	0.57	2.05	0.27	0.18	-0.39	0.95	-0.57	0.38	-0.37	-0.86	-1.03
7	-1.14	0.43	0.85	0.37	1.67	-0.97	-2.54	0.61	1.77	-0.23	-0.80	-1.74	-4.23	1.42	0.08	-1.41
8	-2.50	-1.44	0.99	-4.71	1.36	-0.78	-1.04	0.89	1.48	-0.69	1.44	-1.59	-2.24	0.68	-1.47	2.39
9	-0.85	5.80	1.16	0.89	0.76	-0.60	-0.69	0.86	0.42	-1.28	0.18	-0.14	-1.69	0.20	-1.16	-0.32
10	-1.02	6.35	0.23	0.58	0.41	-0.03	-0.71	-0.53	0.06	-1.05	0.33	0.27	0.21	-0.14	-0.24	-0.83
11	1.30	-0.75	-6.05	-0.11	-1.89	-0.28	-1.21	1.12	1.80	0.30	-0.72	-0.63	-0.49	-1.24	1.13	1.92
12	6.03	-1.17	-1.08	0.54	-0.78	-0.38	0.74	-0.95	0.41	1.72	-0.02	-0.86	0.44	0.13	-0.85	-0.08
13	-2.17	1.28	1.01	-0.09	2.89	-0.49	-0.26	0.36	1.32	-0.09	3.63	1.37	-0.78	1.14	1.83	2.30
14	-0.49	-1.56	1.43	1.03	-0.12	-0.92	1.13	0.41	-0.51	4.95	-1.65	1.02	2.22	-0.23	-1.10	-1.05
15	-0.46	-0.21	-0.06	1.06	-6.09	-0.16	2.11	0.60	0.38	1.06	1.03	-0.14	-0.99	-0.24	-0.03	0.48
16	-0.58	-2.40	0.74	2.01	1.58	-0.78	-1.13	1.39	1.61	-0.68	-0.17	-0.89	3.79	1.21	0.26	-2.66
17	0.20	-1.12	0.43	1.05	-4.43	-0.28	2.26	0.78	-1.21	3.77	0.39	0.14	-0.20	-0.76	-0.84	0.08
18	0.15	0.38	-1.18	0.69	-2.52	-0.06	5.57	1.06	0.34	2.47	-0.03	-0.67	-0.06	0.84	-0.46	-0.48
19	-1.77	2.11	1.56	0.79	1.05	-0.08	-1.45	1.27	0.75	-3.81	0.23	-0.46	2.40	1.60	0.02	0.21
20	0.05	-0.11	0.10	0.29	1.01	-0.96	-0.35	-0.76	1.00	0.47	-0.95	-0.86	4.95	0.75	-1.05	-1.24
21	-0.30	-0.98	-0.17	0.37	-0.07	0.02	-0.28	0.40	0.20	-0.41	-0.58	-0.38	-0.44	-0.05	-0.33	6.55
22	-2.45	0.10	1.13	-2.70	0.90	-1.10	-2.61	0.93	1.18	-1.61	-2.87	-1.31	-0.56	0.77	-1.34	-0.30
23	0.86	-2.24	0.39	3.26	-1.98	-0.73	2.61	0.99	-0.58	-0.65	2.33	0.52	-0.67	0.14	-2.69	-0.84
24	-0.61	3.14	0.05	0.67	0.29	-1.05	-4.03	1.15	1.03	-0.46	0.62	-1.05	-0.26	1.46	1.93	0.45
25	0.56	-0.02	0.52	0.55	-0.17	-0.22	-0.81	-6.62	-0.53	-0.22	0.64	-0.34	0.61	0.35	0.76	-0.28
26	0.91	0.20	0.91	0.68	1.22	-0.21	0.44	-1.02	-6.24	0.79	0.19	-0.60	-0.71	-1.42	1.37	-0.02
27	-0.80	-1.71	-0.05	0.78	-0.22	-0.11	-0.72	-1.90	-0.76	-0.79	0.69	-0.39	-0.92	0.30	6.21	-0.48
28	-0.96	-1.01	0.71	0.96	-2.63	0.26	-0.63	-0.69	-4.51	0.41	2.25	2.14	-0.07	0.90	-0.77	-0.75
29	-0.43	-0.40	0.05	0.08	0.39	9.20	0.00	0.49	0.32	-0.36	0.03	0.29	-0.54	-0.36	-0.16	-0.04
30	-0.80	-0.13	0.37	0.20	1.50	-0.27	1.05	-4.92	-1.25	0.56	0.15	0.47	-0.14	0.05	3.15	-0.37
31	-0.61	0.22	-0.49	0.21	0.11	0.40	-0.38	0.51	-0.35	0.24	0.25	-0.17	-0.29	-7.94	-0.24	0.02

16	IX.	DC level establishing circuits	Negative
17	X.	Diode circuits	Positive
18	XI	Voltage reducing circuits	Positive
19	XII.	Matching circuits	Positive
20	XIII.	Frequency selection circuits	Positive
21	XIV.	Inverter circuits	Negative
22	XV.	High frequency wave component favoring circuits	Positive
23	XVI.	Information and coding circuits	Positive

Discussion

A solution to a multidimensional scaling analysis or a factor analysis problem which produces a rather large number of dimensions or factors relative to the number of original variables may not possess as much appeal as one that reduces the original complex to a smaller set of underlying factors. In the case of the analysis described here the ratio of the number of dimensions to the number of original variables was approximately one-half; generally one hopes to reduce the input variables by more than this. In the first application of multidimensional scaling to job performance (Schultz and Siegel, 1962), 18 original variables were reduced to 4 dimensions. In the second study (Siegel and Schultz, 1963), 29 variables were accounted for in terms of 9 dimensions. By contrast, the outcome of the present study does not seem to be as satisfactory. Yet there is nothing improper or unacceptable, as such, with a large number of dimensions. The basis for the ultimate acceptance or rejection of

Table 8

Circuits with Highest Projections on Dimension I

Circuit No.	Loading	Circuit
5	+ 6.89	Attenuator
12	+ 6.03	Filter
4	+ 3.52	Waveguide
13	- 2.17	Thyratron trigger
22	- 2.45	RF oscillator
8	- 2.50	Magnetron

Table 9

Circuits with Highest Projections on Dimension II

Circuit No.	Loading	Circuit
10	+ 6.35	Flip-flop
9	+ 5.80	Single-shot multivibrator
24	+ 3.14	Blocking oscillator
19	+ 2.11	Sweep oscillator
23	- 2.24	Regulator
16	- 2.40	Automatic frequency control

Table 10

Circuits with Highest Projections on Dimension III

Circuit No.	Loading	Circuit
3	+ 2.57	Klystron
11	- 6.05	Transformer
6	- 7.66	Servomechanism

Table 11

Circuits with Highest Projections on Dimension IV

Circuit No.	Loading	Circuit
23	+ 3.26	Regulator
16	+ 2.01	Automatic frequency control
22	- 2.70	RF oscillator
3	- 2.72	Klystron
8	- 4.71	Magnetron
4	- 6.61	Waveguide

Table 12

Circuits with Highest Projections on Dimension V

Circuit No.	Loading	Circuit
13	+ 2.89	Thyratron trigger
18	- 2.52	Bridge
28	- 2.63	DC restorer
17	- 4.43	Rectifier
15	- 6.09	Voltage doubler

Table 13

Circuits with Highest Projection on Dimension VI

Circuit No.	Loading	Circuit
29	+ 9.20	Cathode ray tube

Table 14

Circuits with Highest Projections on Dimension VII

Circuit No.	Loading	Circuit
18	+ 5.57	Bridge
23	+ 2.61	Regulator
17	+ 2.26	Rectifier
15	+ 2.11	Voltage doubler
6	+ 2.05	Servomechanism
7	- 2.54	Ringing
22	- 2.61	RF oscillator
24	- 4.03	Blocking oscillator

Table 15

Circuits with Highest Projections on Dimension VIII

Circuit No.	Loading	Circuit
30	- 4.92	Differentiator
25	- 6.62	Integrator

Table 16

Circuits with Highest Projections on Dimension IX

Circuit No.	Loading	Circuit
28	- 4.51	DC restorer
26	- 6.24	Clipping

Table 17

Circuits with Highest Projections on Dimension X

Circuit No.	Loading	Circuit
14	+ 4.95	Detector
17	+ 3.77	Rectifier
18	+ 2.47	Bridge
3	- 3.67	Klystron
19	- 3.81	Sweep oscillator

Table 18

Circuits with Highest Projections on Dimension XI

Circuit No.	Loading	Circuit
13	+ 3.63	Thyratron trigger
23	+ 2.33	Regulator
28	+ 2.25	DC restorer
22	- 2.87	RF oscillator
1	- 6.42	Mixer

Table 19

Circuits with Highest Projections on Dimension XII

Circuit No.	Loading	Circuit
2	+ 7.15	Cathode follower
28	+ 2.14	DC restorer
3	- 2.26	Klystron

Table 20

Circuits with Highest Projections on Dimension XIII

Circuit No.	Loading	Circuit
20	+ 4.95	Frequency discriminator
16	+ 3.79	Automatic frequency control
19	+ 2.40	Sweep oscillator
14	+ 2.22	Detector
8	- 2.24	Magnetron
7	- 4.23	Ringing

Table 21

Circuits with Highest Projections on Dimension XIV

Circuit No.	Loading	Circuit
31	- 7.94	Inverter

Table 22

Circuits with Highest Projections on Dimension XV

Circuit No.	Loading	Circuit
27	+ 6.21	Peaking
30	+ 3.15	Differentiator
23	- 2.69	Regulator

Table 23

Circuits with Highest Projections on Dimension XVI

Circuit No.	Loading	Circuit
21	+ 6.55	Modulator
8	+ 2.39	Magnetron
13	+ 2.30	Thyratron trigger
16	- 2.66	Automatic frequency control

the solution should probably be framed in terms of the meaningfulness and utility of the dimensions uncovered.

Generally, the circuit groupings produced in this study appeared to be logical and meaningful. Of the 16 dimensions in the final matrix, the interpretation of 12 seemed fairly clear. Some novel groupings were produced which might not have been suggested in the absence of the multidimensional scaling data.

On the negative side, somewhat less confidence is felt in the interpretation of Dimensions VII, IX, XI, and XIV (balancing, DC level establishing, voltage reducing, and inverter) than in the interpretation of the other dimensions. Also, the precise nature of the difference between the two "regulating" dimensions, III and IV, is not clear. In general, the interpretation of the circuit dimensions seemed somewhat more difficult than the interpretation of the task dimensions in the previous two multidimensional scaling studies (Schultz and Siegel, 1962; Siegel and Schultz, 1963). It is not known whether this was caused by the inherent nature of the subject matter involved or by the inadequacies of the method.

It was mentioned in the earlier reports that since the last stage in a multidimensional scaling analysis involves factor analysis methods, the outcomes are limited by the input data. In the present study, the input data were derived from a list of circuits which had been constructed according to guidelines stressing the inclusion of <u>different</u> types of circuits. A question may be raised, then, as to the degree of "purity" or "independence" that was attained in that list and the resultant effect on the dimensionality structure.

If the difficulties lie with the original circuit list as developed, it might be fruitful to apply other classificatory schemes to the circuit constellation. A stimulus list of circuits described in terms more functionally related to troubleshooting skills might produce a more efficient underlying structure. Or, on the other hand, it might be helpful to start with terms at the whole-equipment level. Some thought should perhaps be given to the possible utility of such alternative approaches to the stimulus list development.

If no more efficient descriptive system is found, the 16 dimensions produced in this study as underlying the circuits worked on by aviation electronics technicians might be accepted for use in further investigations. Such work might take the form of developing unidimensional scales for some or all of the dimensions. Or they might be utilized in a cross-dimensional description of the AT's job by relating them to the task dimensions found in the previous studies. The potential utility and application of the outcomes of multidimensional scaling analyses have been fully discussed in the earlier reports and in the introductory chapter of this report.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

Two recent studies (Schultz and Siegel, 1962; Siegel and Schultz, 1963), carried out at Applied Psychological Services, investigated the applicability of multidimensional scaling techniques to the tasks performed by Naval aviation electronics technicians at two job levels. Specific techniques were developed and the fruitfulness of the multidimensional methods in this situation were demonstrated. The study described in this report approached the aviation electronics technician's job from another standpoint--that of the avionic circuits on which he works. The study was designed to extend the general investigation of the applicability of multidimensional scaling techniques in the job performance area by using the techniques with a somewhat different kind of source data.

The specific objectives of the present study were to: (1) assess the value of multidimensional scaling techniques for classifying avionic circuits, (2) adapt and investigate previously devised methods for applying these techniques to avionic circuits, and (3) determine the number and the nature of the dimensions underlying the circuits repaired by Naval aviation electronics technicians.

Similar procedures and analogous forms to those of the earlier work were used. The same judges were involved. A list of circuits which a Naval aviation electronics technician might normally be expected to work on was developed by an engineer knowledgeable in aviation electronics maintenance. When this list was presented to a group of AT instructors possessing long and varied experience in the rating, there was considerable agreement among them that 31 of the 34 circuits on the original list constituted all the avionic circuits that are characteristically worked on by aviation electronics technicians.

The 31 circuit names were printed in a booklet, arranged in such a way that each circuit could be compared with every other one. A group of chief and first class petty officers in the AT rating then made a similarity judgment for each circuit pair. The judgments were analyzed by the method of equal appearing intervals to produce a matrix of scale values which, in multidimensional scaling, are taken as the inter-stimulus (in this case, inter-circuit) distances.

The usual multidimensional scaling analysis methods were then utilized. First, the technique described by Messick and Abelson was applied to obtain a constant which, when added to the inter-circuit distances, would place them on a ratio, rather than merely an interval, scale. A matrix of scalar products was computed from the "absolute" distance values and was factored by the method of principal components. The extracted factor, or dimensional, matrix was rotated to orthogonal simple structure as defined by the equamax criterion.

The spatial system arising out of the analysis involved sixteen dimensions. Examination of the groups of circuits with the highest loadings produced the following names for these underlying dimensions:

I. Frequency reducing circuits
II. Triggered circuits
III. Regulating circuits
IV. Error compensating circuits
V. Power supply circuits
VI. Electron beam displacement circuits
VII. Balancing circuits
VIII. Wave shaping circuits
IX. DC level establishing circuits
X. Diode circuits
XI. Voltage reducing circuits
XII. Matching circuits
XIII. Frequency selection circuits
XIV. Inverter circuits
XV. High frequency wave component favoring circuits
XVI. Information and coding circuits.

Although sixteen dimensions seemed like a large number relative to the number of original variables, the groupings appeared to be meaningful in most cases and, therefore, seemed to constitute a tentative descriptive system of the factors underlying the circuits repaired by Naval aviation electronics technicians. It was suggested that attempts be made to develop alternative approaches in the circuit-equipment area.

Conclusions

The following conclusions seem warranted by the results of the study described in this report:

1. It is feasible to apply multidimensional scaling techniques to the problem of classifying electronic circuits repaired in the performance of Naval jobs.

2. The methods and materials previously developed for utilizing multidimensional scaling techniques in the job performance area can, with slight modification, be applied to electronic circuits as the stimulus materials.

3. The avionic circuits worked on by Naval aviation electronics technicians, as represented in the circuit list developed in this study, are perceived by supervisory personnel in the rating as involving sixteen underlying dimensions.

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APPENDIX A

Appendix A presents the matrix B^*

Appendix A

Matrix B^* of Scalar Products with Origin at Centroid of Stimuli

	1	2	3	4	5	6	7	8	9	10
1	44.8586	10.6373	10.7594	-9.0965	-4.6317	-11.5117	4.7441	-10.8329	-0.6057	-1.8967
2	10.6373	53.5071	-16.8966	-13.2035	13.4514	-7.3047	-8.1799	-12.0787	1.0469	0.1333
3	10.7594	-16.8966	47.7278	24.5094	-8.0954	-12.0823	9.5815	33.1944	-0.1521	-5.4136
4	-9.0965	-13.2035	24.5094	65.7746	39.6605	-3.5350	0.0698	27.6376	-8.5292	-14.7093
5	-4.6317	13.4514	-8.0954	39.6605	59.5170	-3.3653	-11.4251	-13.0042	-12.4647	-10.3691
6	-11.5117	-7.3047	-12.0823	-3.5350	-3.3653	69.2457	-6.8987	-6.9718	-7.0236	-4.8256
7	4.7441	-8.1799	9.5815	0.0698	-11.4251	-6.8987	44.1988	19.7834	17.0486	7.3106
8	-10.8329	-12.0787	33.1944	27.6376	-13.0042	-6.9718	19.7834	52.0712	-2.2098	-10.5112
9	-0.6057	1.0469	-0.1521	-8.5292	-12.4647	-7.0236	17.0486	-2.2098	49.1908	36.5295
10	-1.8967	0.1333	-5.4136	-14.7093	-10.3691	-4.9256	7.3106	-10.5112	36.5295	48.5708
11	8.2768	-9.1339	-18.0259	5.9375	-4.9184	40.8017	-6.6022	-1.5292	-14.5416	-8.0067
12	-2.1032	-4.9749	-17.2559	14.8650	37.7604	1.8404	-13.5789	-15.6530	-17.2072	-16.1552
13	-13.4716	7.2126	0.7265	-9.7512	-15.9809	-5.8771	5.3284	23.0986	13.8062	13.4963
14	19.9607	13.0671	-9.1219	-7.8403	-4.6707	-7.0961	-11.2968	-15.3519	-12.0357	-14.5917
15	-11.3326	-2.7643	-12.3004	-9.9589	-11.2412	-7.4123	-10.5864	-7.9427	-2.7583	-6.4888
16	4.7685	-6.2911	20.9548	-8.3199	-4.2226	4.3390	3.9998	-10.1621	-13.7543	-6.8089
17	-7.1905	2.1956	-20.4164	-11.7333	-2.2292	-8.8467	-16.8661	-11.8289	-13.2691	-13.1415
18	2.0798	-4.7905	-12.7914	-5.4458	-0.6211	19.6327	-14.3339	-13.0882	-9.5311	-5.3596
19	-1.6395	0.7867	20.2143	-9.2570	-17.9694	-9.9987	6.5000	6.3588	21.2885	20.5669
20	8.4941	-6.5543	3.8878	2.0882	-2.9415	3.2274	-10.7017	-11.1000	-5.3158	-1.0273
21	9.3939	-5.5021	-0.1256	-8.1765	-4.7474	-3.7313	-1.6943	17.8259	-4.6254	-11.9645
22	20.5135	-6.2524	35.5828	9.7127	-15.6388	-13.1801	22.1414	34.4245	9.7433	2.8896
23	-11.2155	3.2689	-4.0691	-8.3511	2.0276	4.9567	-9.3288	-13.5115	-5.5860	-14.2577
24	-5.2089	-8.3760	-1.5336	-14.0669	-9.7351	-11.3030	20.3825	4.0918	24.0783	21.7920
25	-10.8198	-4.2706	-3.0442	-9.5874	-[illegible].2216	-6.8182	-4.8086	-11.3518	-4.7631	4.1954
26	-8.5033	-4.7043	-14.6498	-10.4103	16.1569	-6.4888	-10.5228	-12.1432	-1.1224	-0.1447
27	-9.3913	-4.1153	-7.0049	-7.4073	-7.4972	-5.4441	5.9008	-10.5546	-12.7715	-12.3049
28	-15.7902	12.8525	-17.1144	-1[illegible].4567	2.5420	-8.1538	-12.4684	-12.5116	-9.0252	-1.5619
29	-0.2391	6.2465	-4.3059	2.7943	0.0281	6.8108	-6.3094	-3.2128	-4.8939	-2.1046
30	-3.2491	2.4401	-15.9830	-9.2136	-3.1443	-0.1916	-3.1870	-8.6718	-10.1120	3.2054
31	-5.7572	-1.4329	-6.2122	-3.5001	-2.0088	7.2060	-8.2008	-4.2647	-0.4344	2.9534

Matrix of Scalar Products with Origin at Centroid of Stimuli (con't.)

	11	12	13	14	15	16	17	18	19	20
1	8.2768	-2.1032	-13.4716	19.3607	-11.3326	4.7685	-7.1905	2.0798	-1.6395	8.4941
2	-9.1339	-4.9749	7.2126	13.0671	-2.7643	-6.2911	2.1956	-4.7905	0.7867	-6.5543
3	-18.0259	-17.2559	0.2265	-9.1219	-17.3004	20.9548	-20.4134	-12.7914	20.2143	3.8878
4	5.9375	14.8650	-9.7512	-7.8403	-9.9589	-8.3199	-11.7333	-5.4458	-9.2570	2.0882
5	-4.9184	37.7604	-15.9439	-4.6707	-11.2412	-4.2226	-2.2292	-0.6211	-17.9694	-2.9415
6	40.8017	1.8454	-5.8771	-7.0361	-7.4123	4.3390	-8.8467	19.6327	-9.9987	3.2274
7	-6.6022	-13.5789	5.3284	-11.2969	-10.5864	3.9998	-16.8661	-14.3339	6.5000	-10.7017
8	-1.5292	-15.6530	23.0986	-15.3519	-7.9427	-10.1621	-11.8289	-13.0482	6.3588	-11.1000
9	-14.5416	-17.2572	13.8062	-12.0357	-7.7583	-13.7543	-13.2691	-9.5311	21.2885	-5.3158
10	-8.0067	-16.1552	13.4963	-14.5917	-6.4888	-6.8089	-13.1415	-5.3596	20.5669	-1.0273
11	50.5521	20.2177	-7.4478	-14.0338	13.5622	-8.6006	7.4214	-0.5671	-15.9688	-7.4240
12	20.2177	46.3865	-19.4588	5.9283	3.6456	0.6685	17.1396	13.7432	-18.9626	3.0542
13	-7.4478	-19.4588	43.5492	-11.2112	-14.8317	-2.2564	-18.8612	-10.9459	10.9022	-9.0245
14	-14.0338	5.9283	-11.2112	38.9893	6.1791	16.6725	29.5879	16.1555	-21.8109	18.6540
15	13.5622	3.6456	-14.8317	6.1791	49.3358	-12.4933	34.4649	30.1356	-16.4770	-9.8664
16	-8.6006	0.6685	-2.2564	16.6725	-12.4933	41.2436	-9.6106	-10.4974	21.6050	24.6697
17	7.4214	17.1396	-18.8612	29.5879	34.4649	-9.6106	44.3961	35.6436	-19.5011	-10.3002
18	-0.5671	13.7432	-10.9459	16.1555	30.1356	-10.4974	35.6436	50.1250	-16.0824	-2.0429
19	-15.8684	-18.9626	10.9022	-21.8109	-16.4770	21.6050	-19.5011	-16.0824	40.0374	14.1729
20	-7.4240	3.0542	-9.0245	18.6540	-9.8664	24.6697	-10.3002	-2.0429	14.1729	36.6131
21	14.1107	-6.3412	9.4248	-5.6289	5.0806	-14.1007	-0.6227	-4.3649	2.5532	-8.3655
22	-5.7110	-17.8632	-2.7356	-11.3414	-17.4800	5.6874	-16.8922	-19.9948	17.7129	7.9833
23	-4.3901	12.8466	-4.6531	6.2375	24.4487	3.0246	22.1155	18.8982	-9.6474	-0.4730
24	6.6050	-13.3208	17.7528	-13.6469	-7.4097	3.8318	-21.5837	-17.3836	19.5016	0.7529
25	-10.8985	10.3954	-2.4456	-1.3997	-9.1175	-7.1984	-6.8510	-9.2616	-5.5861	7.1906
26	-14.4735	6.5056	-5.1468	7.0471	-7.3177	-16.5575	5.8607	-5.7654	-9.1468	-8.6149
27	6.3234	-9.7016	11.5688	-11.4242	-2.0689	2.3198	-5.8641	-7.6109	-2.7460	-8.7346
28	-15.7022	-8.7665	-1.5818	6.7909	16.6252	-4.0675	20.3733	1.4221	-7.2964	-9.9000
29	-3.0132	-6.6788	-1.5838	-13.2858	-2.3129	-6.7146	-4.6644	-3.2267	-0.2630	-11.3032
30	-14.6826	-1.2140	8.8644	-2.8580	-2.5946	-1.7756	-5.1643	-9.0047	-7.7440	0.7037
31	11.2624	-6.0013	-7.9659	0.4759	1.2379	-10.3535	6.2324	-5.1256	-12.2034	-7.8022

Matrix β^* of Scalar Products with Origin at Centroid of Stimuli (con't.)

	21	22	23	24	25	26	27	28	29	30	31
1	9.3939	20.5135	-11.2155	-5.2389	-10.8198	-8.5033	-9.3913	-15.7902	-0.2391	-3.2491	-5.7572
2	-5.5021	-6.2524	3.2689	-8.3960	-4.2706	-4.7043	-4.1153	12.8525	6.2465	2.4401	-1.4329
3	-0.1256	35.5828	-4.0691	-1.5836	-3.0442	-14.6498	-7.0049	-17.1144	-4.3059	-15.9830	-6.2122
4	-8.1765	9.2127	-8.3511	-14.0669	-9.5874	-10.4109	-7.4073	-10.4567	2.7943	-9.2136	-3.5001
5	-4.7474	-15.6388	2.0276	-9.7351	-0.2216	16.1569	-7.4972	2.5420	0.0281	-3.1443	-2.0088
6	-3.7313	-13.1801	4.9567	-11.3030	-6.8182	-6.4888	-5.4441	-8.1538	6.8108	-0.1916	7.2060
7	-1.6943	22.1414	-9.3284	20.3825	-4.8086	-10.5228	5.9008	-12.4684	-6.3094	-3.1870	-8.2008
8	17.8259	34.4245	-13.5115	4.0918	-11.3518	-12.1432	-10.5546	-12.5116	-3.2128	-8.6718	-4.2647
9	-4.6254	9.7433	-5.5860	24.0783	-4.7631	-1.1224	-12.7715	-9.0252	-4.8939	-10.1120	-0.4344
10	-11.9645	2.8896	-14.2577	21.7920	4.1954	-0.1447	-12.3049	-1.5619	-2.1046	3.2054	2.9534
11	14.1107	-5.2110	-4.3901	6.6050	-10.8985	-14.4735	6.3234	-15.7022	-3.0132	-14.6826	11.2624
12	-6.3412	-17.8632	12.8466	-13.3208	10.3954	6.5056	-9.7016	-8.7665	-6.6788	-1.2140	-6.0013
13	9.4248	-2.7356	-4.6531	17.7528	-2.4456	-5.1468	11.5688	-1.5818	-1.5838	8.8644	-7.9659
14	-5.6289	-11.3414	6.2375	-13.6469	-1.3997	7.0471	-11.4242	6.7909	-10.2858	-2.8580	0.4759
15	5.0806	-17.4800	24.4487	-7.4097	-9.1175	-7.3177	-1.0689	16.6252	-2.3129	-2.5946	1.2379
16	-14.1007	5.6874	3.0246	3.8318	-7.1984	-16.5575	2.3198	-4.0675	-6.7146	-1.7756	-10.3535
17	-0.6227	-16.8922	22.1155	-21.5837	-6.8510	5.8607	-5.8641	20.3733	-4.6644	-5.1643	6.2324
18	-4.3649	-19.9948	18.8982	-17.3836	-3.2616	-5.7654	-7.6109	1.4221	-3.2267	-9.0047	-5.1256
19	2.5532	17.7129	-9.6474	19.5016	-5.5861	-9.1468	-2.7460	-7.2964	-0.2630	-7.7440	-12.2034
20	-8.3655	7.9833	-0.4730	0.7529	7.1906	-8.6149	-8.7346	-9.9000	-11.3032	0.7037	-7.8022
21	48.0641	-1.6995	-4.6111	1.5447	-4.0940	-5.2366	-3.4163	-4.9737	0.3273	-6.0641	1.7609
22	-1.6995	38.0314	-20.3076	16.3260	-10.8605	-13.9262	-10.3887	-14.6048	-7.3743	-9.5526	-4.9451
23	-4.6111	-20.3076	46.3494	-19.7150	-7.7446	1.7470	-10.3579	20.1097	-4.6373	-11.3189	-1.8551
24	1.5447	16.3260	-19.7150	37.6562	-0.9806	-7.8917	9.9439	-6.5349	-10.0599	-6.8503	-8.5887
25	-4.0940	-10.8605	-7.7446	-0.9806	47.9952	7.7500	22.6498	12.5686	-6.4589	31.2456	-5.4083
26	-5.2366	-13.9262	1.7470	-7.8917	7.7500	47.9685	15.8322	23.2347	-3.5898	22.3712	11.8827
27	-3.4163	-10.3887	-10.3579	9.9439	22.6498	15.8322	49.1466	4.4632	-1.5811	26.1812	-3.9445
28	-4.9737	-14.6048	20.1097	-6.5349	12.5686	23.2347	4.4632	42.5926	0.4504	1.5142	-5.0295
29	0.3273	-7.3743	-4.6373	-10.0599	-6.4589	-3.5898	-1.5811	0.4504	86.2278	-4.9158	6.8440
30	-6.0641	-9.5526	-11.3189	-6.8503	31.2456	22.3712	26.1812	1.5142	-4.9158	45.0787	-4.1127
31	1.7603	-4.9451	-1.8551	-8.5887	-5.4083	11.8827	-3.9445	-5.0295	6.8440	-4.1127	65.2914

APPENDIX B

Appendix B presents the matrix F

Appendix B

The Unrotated Matrix

Dimension Number

Task Number	I	II	III	IV	V	VI	VII	VIII
1	-0.8903	-1.4660	-1.0251	2.6574	1.7964	0.9826	1.9364	4.4526
2	1.1399	1.7793	-0.0027	1.3345	-0.9103	3.1470	1.8296	1.5696
3	-4.3908	-3.3931	0.5106	2.2160	-1.3270	-1.3715	1.0235	-1.3358
4	-0.6947	-5.6966	4.0096	-0.9598	-2.2135	0.7419	-1.4885	-1.0569
5	7.6215	-2.4610	5.1170	-0.1352	-1.0052	3.3012	-2.2138	0.3796
6	1.7416	-1.6343	-1.5011	-3.8397	5.1271	0.3028	0.2449	-2.5729
7	-3.0784	0.0204	-0.5208	-0.3729	-0.5070	-0.8937	-1.0276	0.6700
8	-4.1620	-3.1969	-0.1413	-1.6219	-3.5114	-2.6772	0.4632	-0.1692
9	-3.3761	2.4760	-2.2951	-0.3373	-0.9190	3.0545	-1.0777	0.2035
10	-2.7206	3.4456	-1.5203	-0.4906	0.5394	3.2418	-2.6642	-0.1625
11	1.5730	-2.7621	-1.8464	-4.4914	3.4103	-1.1317	-0.8458	1.6406
12	4.0280	-2.4614	2.4655	0.1214	1.2677	0.6156	-2.6096	0.5176
13	-3.0141	2.4728	-0.3992	-1.6729	-1.0823	-0.9742	0.2145	-1.1030
14	3.0753	-0.1285	-0.7963	4.3388	0.5258	-0.2575	1.2776	1.0916
15	3.8492	0.1621	-3.7091	-0.2439	-2.1948	-1.8176	-1.0161	-0.6006
16	-1.3323	-0.8510	0.2701	3.9139	3.3125	-0.7175	1.1862	-2.1094
17	5.3190	-0.0729	-2.5482	1.2411	-2.0258	-1.1932	-0.3408	0.6483
18	4.3922	-1.0403	-3.0738	0.4782	-0.0776	-0.4964	-1.0409	-1.1652
19	-4.5370	1.1558	-0.9848	1.5545	0.7054	0.9805	-0.1338	-2.0336
20	-0.5727	-0.7075	0.6210	3.6134	3.3657	0.1823	-0.0431	-0.7805
21	-0.5757	-0.8797	-1.5157	-2.0420	-1.1498	-1.8980	1.2659	2.5591
22	-5.0471	-2.1782	-0.4848	1.3752	-0.5821	-0.6219	0.3725	1.4622
23	3.6846	-0.2782	-1.8925	1.4721	-1.4334	-0.3222	-0.6980	-2.9180
24	-3.9278	2.5306	-0.9357	-3.0778	0.9771	-0.7754	-2.2960	0.5291
25	0.5502	3.2351	3.6435	0.5638	1.0746	-1.3431	-0.7163	-0.1983
26	2.1798	3.1382	3.0457	-0.4912	-1.3751	0.1377	-1.2032	1.1443
27	-0.0058	3.1388	2.6435	-1.8320	1.0510	-3.6311	1.2193	-0.1725
28	2.4233	3.0379	0.2653	0.7154	-2.7363	-0.3731	0.4296	-1.6123
29	0.3228	-0.3300	-0.0464	-2.4791	-1.0541	4.2078	4.2311	-2.4075
30	0.6294	3.7374	3.4431	-0.4932	1.0890	-2.0570	0.9435	0.4548
31	1.1956	-0.0146	-0.7920	-2.7077	-0.1276	1.5453	1.2732	2.4933

Task Number	IX	X	XI	XII	XIII	XIV	XV	XVI
1	-1.1147	1.2280	-0.7857	0.2170	1.4072	-0.7805	0.2834	1.3971
2	-3.2948	-3.0363	-0.7948	1.5704	-1.9732	-1.7957	0.3943	0.5257
3	1.7195	0.2483	0.0035	-0.3409	0.2971	-0.9883	0.8148	1.5344
4	0.3523	0.4180	-0.9416	0.4257	-1.5917	0.0674	-1.2764	0.6127
5	-1.4540	-0.7622	0.9215	0.1049	0.5847	0.3661	0.0982	-0.7276
6	0.7642	-2.1623	-2.3426	0.8377	1.6068	-1.1007	-0.4572	-0.3260
7	-0.4924	1.2678	-0.1430	3.6037	1.3737	0.5167	2.0276	-1.5934
8	0.0866	-1.3272	-1.5916	-0.3365	-0.1915	0.2773	-0.3811	-1.3355
9	0.5507	0.6756	-0.8117	-0.1187	0.5355	0.1194	0.7127	0.1265
10	1.0236	0.9991	-1.1356	-0.8756	-0.6958	-0.3418	-0.5875	0.2043
11	-1.1302	-0.0116	1.5693	0.3901	-0.6502	-1.0492	-0.9387	-0.1867
12	-1.2862	1.1476	0.9318	-0.9468	0.2001	0.7637	1.4515	-1.1323
13	-2.1366	-2.7760	-1.2275	-0.6866	-0.9877	2.5946	0.3862	0.0669
14	0.5059	-0.7020	-1.2027	0.4927	-0.4169	1.8858	-0.8765	-1.5703
15	-0.2338	2.0002	.8873	0.0170	-1.5215	-0.9292	-0.1824	0.8502
16	0.1375	-0.0698	2.1216	0.8874	-0.3032	1.2223	0.2545	-0.0813
17	0.4988	0.8730	1.1346	0.2556	-0.5347	0.5890	-0.8223	-0.5738
18	-0.1805	1.4338	-2.8941	-0.1403	0.3916	1.2745	-0.1903	1.7444
19	-0.2385	-0.2738	1.6565	-1.4698	0.2512	-0.4057	-0.5019	1.4251
20	0.0233	-0.1676	-0.0606	-1.9421	-0.9279	0.2831	-0.9600	-0.7989
21	-1.9651	-1.0776	1.1386	-3.9402	1.6014	0.1855	0.4744	0.0953
22	0.9141	0.8117	-0.2538	0.9529	0.3962	-1.5718	-0.8216	-0.4950
23	-0.3644	-1.4879	1.1914	0.2303	1.1890	-0.7554	2.7266	0.1067
24	-1.2535	0.7420	2.0955	0.6270	-0.3732	1.0758	-1.2995	-0.9070
25	0.3945	1.7108	-0.9701	-1.9042	-1.1376	-2.1304	1.4411	-1.6939
26	2.5185	-0.7990	0.3199	0.0997	3.4699	0.7577	-1.3946	0.4971
27	-0.7663	1.1326	1.3533	2.0510	-0.6029	0.7046	-0.3047	2.2487
28	0.0107	-1.2453	1.2190	0.6284	0.8199	-2.2018	-2.0697	-1.2570
29	-0.6777	3.3995	0.4309	-0.3275	0.2927	0.8756	-0.0543	-1.0051
30	0.2863	0.5936	-2.4416	-0.2629	-0.4428	-0.1268	0.6149	0.6317
31	5.6895	-1.8166	1.6014	0.1134	-2.0599	0.6346	1.4399	0.2858

APPENDIX C

Appendix C presents the matrix of residuals after extraction of sixteen dimensions from matrix β^*

Appendix C

Residual Matrix after Extraction of Sixteen Dimensions from the Matrix

	1	2	3	4	5	6	7	8	9	10
1	-1.7511	-1.6500	2.5220	0.3431	-0.6021	-3.5428	-0.4588	-3.3704	0.4055	2.0282
2	-1.6500	0.1764	-0.8226	-2.7896	2.0711	0.7311	-0.0359	1.6956	0.1067	-1.8467
3	2.5220	-0.8226	-1.8299	0.4940	0.4324	1.0640	-3.6371	1.4309	-0.2356	1.5921
4	0.3431	-2.7896	0.4940	1.1528	1.4818	-1.1807	1.6396	-0.5536	3.9257	-0.1377
5	-0.6021	2.0711	0.4324	1.4818	-1.1165	1.7194	1.3110	-1.4266	-2.1519	0.7915
6	-3.5428	0.7311	1.0640	-1.1807	1.7194	-2.6574	1.0561	-0.0454	2.5221	-1.5367
7	-0.4588	-0.0359	-3.6371	1.6396	1.3110	1.0561	2.5354	0.9179	-0.7467	1.1457
8	-3.3704	1.6956	1.4309	-0.5536	-1.4266	-0.0454	0.9179	-4.3198	-2.7799	-0.9183
9	0.4055	0.1067	-0.2356	3.9257	-2.1519	2.5221	-0.7467	-2.7799	4.3382	-3.8775
10	2.0282	-1.8467	1.5921	-0.1377	0.7915	-1.5367	1.1457	-0.9183	-3.8775	3.7347
11	5.4748	-0.3029	-1.2510	2.8952	-4.5595	3.9270	-2.9840	0.6068	-1.4685	2.5056
12	-0.5553	1.0906	-0.7682	-3.0551	0.3504	-2.8570	-2.2913	2.8188	-1.1856	-0.5806
13	2.2766	-1.0122	1.4730	-0.5662	-1.8042	-2.2746	-3.5563	2.7754	0.6490	2.6925
14	3.3104	1.5422	0.9453	4.0027	-2.8474	1.4152	-0.0229	-0.9118	3.2157	-1.1915
15	-2.0745	0.2463	0.8064	-0.3115	0.6261	-1.6242	0.6491	0.6521	2.1663	-0.5365
16	-0.9359	-2.0828	4.0097	-2.4364	2.7516	1.7253	1.6636	-1.1724	-2.6638	2.4560
17	-4.1518	0.7100	-0.5757	-2.5838	-0.4300	-2.2435	-0.5505	1.7582	0.1917	0.9197
18	1.3280	0.2555	0.2749	-2.0185	2.3329	3.6960	0.7609	0.3961	-4.1073	0.1743
19	-2.7101	4.3580	-1.3346	-0.4953	-2.9176	-0.3867	1.0450	1.9752	0.5824	-0.3464
20	-0.3446	-0.5091	-5.5397	3.0185	-0.3373	-0.0261	0.4358	-0.8275	0.8554	-2.8363
21	0.1043	-1.3171	-0.8768	0.9483	3.6057	1.3082	3.5015	-0.3922	0.5977	-0.8823
22	2.0638	1.6801	1.5260	-3.4007	-0.6404	-0.5935	-1.2249	5.1716	-0.7272	-1.4900
23	2.5069	-1.0799	0.4096	1.5953	-2.3844	-1.0688	-0.6515	-1.3897	1.3412	-0.6753
24	-1.8777	-0.8503	0.3977	-3.0581	3.4763	-0.8509	-0.3505	-0.4717	0.4552	-0.9447
25	-1.0241	-0.0108	4.9280	-1.7716	0.2650	0.6819	-0.3055	-0.7352	1.4372	0.0205
26	-0.4325	-0.7299	1.2085	-2.4510	0.0197	-0.1324	-1.8777	2.2706	1.1518	-0.2800
27	-0.2513	0.8382	0.7847	2.1711	-1.0507	-1.0624	0.8384	-2.6893	1.8104	-3.5164
28	2.3620	-1.1477	-1.6506	2.7578	0.7315	0.7442	0.3944	-1.8088	-2.4733	2.0845
29	0.6694	0.0235	-0.2696	0.1440	-0.5844	0.2529	-0.6887	0.2520	0.0692	-0.2598
30	1.0861	0.2824	-5.0972	1.2228	-0.5503	1.1347	0.5803	1.3559	-2.2452	1.6993
31	-0.7625	0.3612	-0.2861	-0.5229	1.1854	-0.0579	0.9209	-0.2724	-1.1534	0.0506

Residual Matrix after Extraction of Sixteen Dimensions from the Matrix S^* (con't.)

	11	12	13	14	15	16	17	18	19	20
1	5.4748	-0.5553	2.2766	3.3104	-2.0745	-0.9359	-4.1518	1.3280	-2.7101	-0.3446
2	-0.3029	1.0906	-1.0122	1.5472	0.2463	-2.0828	0.7100	0.2555	4.3580	-0.5091
3	-1.2510	-0.7482	1.4730	0.3453	0.8064	4.0097	-0.5757	0.2749	-1.3346	-5.5397
4	2.8952	-3.0551	-0.5662	4.0027	-0.3105	-2.4864	-2.5838	-2.0185	-0.4958	3.0185
5	-4.5595	0.3504	-1.8082	-2.8474	0.8261	2.7516	-0.4000	2.3329	-2.9176	-0.3373
6	3.9270	-2.8570	-2.2746	1.4152	-1.6242	1.7253	-2.2435	3.6960	-0.3867	-0.0261
7	-2.9840	-2.2713	-3.5563	-0.7229	0.6491	1.6636	-0.5505	0.7609	1.0450	0.4358
8	0.6068	2.8188	2.7754	-0.9118	0.6521	-1.1724	1.7582	0.3961	1.9752	-0.8275
9	-1.4685	-1.1856	0.6490	3.2157	2.1663	-2.6638	0.1917	-4.1073	0.5824	0.8554
10	2.5056	-0.5806	2.6925	-1.1915	-0.5365	2.4560	0.9197	0.1743	-0.3464	-2.8363
11	-5.7143	5.0610	2.7387	-2.4579	2.0308	-0.2911	3.6159	-6.1369	-1.1712	-1.0706
12	5.0610	0.3777	1.6667	-2.2977	-1.8151	2.0779	3.6939	1.1120	3.0758	-2.6792
13	2.7387	1.6667	0.0040	0.5942	-3.0070	0.1388	-1.9729	0.1973	-2.9533	-0.9595
14	-2.4579	-2.2977	0.5942	-4.9995	0.4902	3.9190	3.2130	-1.4130	-5.9351	2.2717
15	2.0308	-1.8151	-3.0070	0.4902	2.3752	1.2175	-3.3967	-0.7171	-2.7738	2.6640
16	-0.2911	2.0779	0.1388	3.9190	1.2175	-2.5936	0.4571	-2.6399	3.1303	-2.8114
17	3.6159	3.6939	-1.9729	3.2130	-3.3967	0.4571	-0.7359	2.7494	5.4809	-4.4821
18	-6.1369	1.1120	0.1973	-1.4130	-0.7171	-2.6399	2.7494	1.7665	1.7595	-0.3437
19	-1.1712	3.0758	-2.9533	-5.9351	-2.7738	3.1303	5.4809	1.7595	0.9365	1.4125
20	-1.0706	-2.6792	-0.9595	2.2717	2.6640	-2.8114	-4.4821	-0.3437	1.4125	3.2965
21	-1.4517	-4.8050	-2.1976	1.7877	1.5354	0.1789	-0.7957	0.2089	1.2034	0.8002
22	0.0203	2.8493	-1.3149	-4.7249	-1.6510	-1.4153	3.0903	0.4214	0.71[illegible]2	2.5943
23	1.4040	0.7434	3.3581	-1.1537	0.8872	-2.3688	-1.2834	-2.3579	-2.8709	4.1353
24	0.9718	-1.3050	0.9737	1.7642	0.9680	-0.7133	-3.9647	2.9478	-1.3804	0.7001
25	-0.7011	1.9766	-0.9743	2.4509	-4.2400	-3.1805	-0.6317	2.5050	-1.0644	-0.2750
26	1.1093	3.7965	-0.4068	2.2338	-0.1869	-3.6300	-0.6351	-2.1505	2.0731	0.5560
27	2.1163	-3.0805	1.2575	-0.1770	-2.2793	-0.8614	0.7571	2.2724	0.0489	0.9865
28	-1.3380	-3.7797	1.7775	-0.4329	0.4957	2.3235	0.3945	0.2956	-1.7420	-1.9179
29	-0.3902	0.6456	0.5138	-0.3796	0.5930	-0.3353	0.0278	-0.7801	-0.2520	0.3357
30	-2.5982	0.8548	0.3338	-3.5482	6.6670	3.8986	1.3651	-4.8656	0.5640	0.5268
31	-0.5774	-1.1568	-0.5002	-0.5873	-0.6427	0.2173	-0.0163	2.0494	-0.0382	0.2666

Residual Matrix after Extraction of Sixteen Dimensions from the Matrix B'' (con't.)

	21	22	23	24	25	26	27	28	29	30	31
1	0.1343	2.0638	2.5069	-1.8777	-1.0241	-0.4325	-0.2513	2.3620	0.6694	1.0861	-0.7625
2	-1.3171	1.6801	-1.0799	-0.8503	-0.0108	-0.7299	0.8382	-1.1477	0.0235	0.2824	0.3612
3	-3.8768	1.5260	0.4096	0.3977	4.9280	1.2085	0.7847	-1.6506	-0.2696	-5.0972	-0.2861
4	0.9483	-3.4007	1.5953	-3.6581	-1.7716	-2.8510	2.1711	2.7578	0.1440	1.2228	-0.5229
5	3.6057	-0.6404	-2.3844	3.4763	0.2650	0.0197	-1.0507	0.7315	-0.5804	-0.5503	1.1854
6	1.3082	-0.5935	-1.0688	-0.8509	0.6819	-0.1324	-1.0624	0.7442	0.2529	1.3347	-0.0579
7	3.5015	-1.2249	-0.6515	-0.3505	-0.3055	-1.8777	0.8384	0.3944	-0.6887	0.5803	0.9209
8	-0.3922	5.1716	-1.3897	-0.4717	-0.7352	2.2706	-2.6893	-1.8088	0.2520	1.3559	-0.2724
9	0.5977	-0.7272	1.3432	0.4552	1.4372	1.1518	1.8104	-2.4733	0.0692	-2.2452	-1.1534
10	-0.8823	-1.4900	-0.6953	-0.9447	0.0205	-0.2800	-3.5164	2.0845	-0.2598	1.6993	0.0506
11	-1.4517	0.0203	1.4040	0.9718	-0.7011	1.1093	2.1163	-1.3380	-0.3902	-2.5982	-0.5774
12	-4.8050	2.8493	0.7434	-1.3050	1.9766	3.7965	-3.0805	-3.7797	0.6456	0.8548	-1.1568
13	-2.1976	-1.3149	3.3581	0.9737	-0.9743	-0.4068	1.2575	1.7775	0.5138	0.3338	-0.5002
14	1.7877	-4.7249	-1.1537	1.7682	2.4509	2.2338	-0.1770	-0.4329	-0.3796	-3.5482	-0.5873
15	1.5354	-1.6510	0.8872	0.9680	-4.2409	-0.1869	-2.2793	0.4957	0.5930	6.6670	-0.6427
16	0.1789	-1.4153	-2.3638	-0.7133	-3.1805	-3.6300	-0.8614	2.3235	-0.3353	3.8986	0.2173
17	-0.7957	3.0903	-1.2834	-3.9647	-0.6317	-0.6351	0.7571	0.3945	0.0278	1.3651	-0.0163
18	0.2089	0.4214	-2.3579	2.9478	2.5050	-2.1508	2.2724	0.2956	-0.7801	-4.8656	2.0494
19	1.2034	0.7102	-2.8709	-1.3804	-1.0644	2.0731	0.0489	-1.7420	-0.2520	0.5640	-0.0382
20	0.8002	2.6343	4.1353	0.7001	-0.2750	0.5560	0.9865	-1.9179	0.3357	0.5268	0.2666
21	2.7845	-3.9003	-1.7791	-0.1105	0.9686	-2.5550	-0.1010	1.2747	-0.6631	0.1144	0.8444
22	-3.9003	-3.0421	-0.0808	3.1640	-1.9596	0.8463	-0.9998	-0.1407	0.3484	2.2535	0.5062
23	-1.7791	-0.0808	2.6697	-0.5702	-1.7186	1.1106	0.3218	0.9508	0.5412	0.0865	-0.5979
24	-0.1105	3.1640	-0.5702	-0.6371	1.2369	-0.7703	0.8333	0.8433	0.3313	-1.8213	0.5860
25	0.9686	-1.9596	-1.7186	1.2369	0.4921	-3.4446	3.7247	3.7650	-0.2066	-3.1701	0.9993
26	-2.5550	0.8463	1.1106	-0.7703	-3.4446	-1.3129	1.6470	0.4939	0.5180	2.7357	-0.3506
27	-0.1010	-0.9998	0.3218	0.8333	3.7247	1.6470	-0.5600	-0.6198	0.0802	-3.2001	-0.0547
28	1.2747	-0.1407	0.9508	0.8433	3.7650	0.4939	-0.6198	-0.7394	-0.4556	-3.5088	0.1101
29	-0.6631	0.3484	0.5412	0.3313	-0.2066	0.5180	0.0802	-0.4556	0.1017	-0.0725	-0.1368
30	0.1144	2.2535	0.0865	-1.8213	-3.1701	2.7357	-3.2001	-3.5088	-0.0725	4.6483	-0.9316
31	0.8444	0.5062	-0.5979	0.5860	0.9993	-0.3506	-0.0547	0.1101	-0.1368	-0.9316	0.6198